

The Maryland Fruit Grower

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SOIL MOISTURE AND ITS RELATION TO ORCHARDING *

By C. C. Wiggans, Horticulture Department, University of Nebraska

There is an old saying, "You never miss the water until the well runs dry." We all have realized that the past several seasons have been drier than usual, but until we began to see our trees wilt and then had to harvest the small-sized fruit, we gave little thought to the problem as to whether or how the tree can secure enough water to survive such conditions.

In Nebraska perhaps a keener appreciation of what probably was happening in our orchards developed a few years ago when the first report agronomical investigations of the subsoil-moisture situation in an alfalfa planting was made available. Very clearly it was shown that a planting of alfalfa on virgin soil produced well for a few years, regardless of seasonal rainfall, but then the production declined and became directly proportional to annual precipitation. Tests showed that the roots penetrated to depths of 25 feet or more and that the soil was dried out to the same depth.

A second fact which stimulated our thinking further was a knowledge of how far and how fast an apple-tree root can develop. In an investigation dealing with newly set Delicious trees, the entire root system of several trees under various types of soil management were dug at the end of the first growing season. Others were dug after the second season, and still others after the third. To our very great surprise these roots were found to have penetrated in three seasons to a depth of 16 feet or more and to have a spread of perhaps 20 feet. Although the tree tops were not much higher than one's head, there had been a tremendous development underground.

Following this as a lead during the summer of 1934 an effort was made to determine the extent and density of the root system of a 17-year-old Jonathan tree. These trees were spaced 30x33 feet. One quarter of this area was dug out, by three-foot sections, and root counts made at varying distances from the tree and at various depths. Digging continued downward as long as roots were found. When the job was completed we had a hole 15x16½ feet and 30 feet deep. Further depth penetration had been prevented by an impenetrable shale layer. Roots were found all through this area. Even with such limitations each tree was drawing upon a volume 30x33x30 feet of moisture and food supply—a total volume of approximately 1,000 wagonloads. Whether roots might have gone deeper provided suitable soil conditions had been present, is merely conjecture, but there seems little reason to believe that they would not have done so.

With these facts in hand, the next question to be answered was, What effect is such widespread deep rooting having on the moisture content of the soil? Obviously the only reason for the observed rooting habit must be an

* From Biennial Report of Kansas State Horticultural Society, 1936.

effort to supply the moisture needs of the tree, since there would be little or no need or possibility for minerals or nitrogen to be brought up from such depths. Consequently, soil samples were collected from various points and from varying distances from trees of different ages and varieties. Such samples were secured by using a standard steel soil-sampling tube. This was driven into the soil lifted with a pump jack, the soil core removed, and divided into one-foot sections, which were preserved in tight containers. Such samples were taken to the laboratory, weighed, dried and then weighed again. Weight loss was used to measure the water content. This was then calculated as a percentage of the dry soil weight. Thus we were able to determine the soil-moisture content of various portions of the root zone.

When considering soil moisture one must always bear in mind that not all the water content of the soil is available for plant use. A plant will die from water starvation even though a considerable percentage of water remains in the soil. This unavailable water is called by various terms, such as wilting coefficient, hygroscopic coefficient, etc., and the amount depends upon soil texture or soil particle size. The finer the soil particles are the more water they will hold against the pull of plant roots. In this discussion the term hygroscopic coefficient is used.

The soil in the area where this work has been done is classed as "loess," the same sort as is found in the hills all along the Missouri and Mississippi rivers. Under normal conditions the water-holding capacity of this soil is around 25 per cent. If more water is added after this point is reached that which is already present is simply pushed down deeper or else the additional water gets away as runoff without ever really entering the soil. The hygroscopic figure varies from about 10 to 12 per cent. Thus it will be seen that the available soil moisture is approximately 15 per cent. In loess soil available water averages 2-2¼ inches of water per foot of depth. These figures represent the reserve which should be in the soil at the time the orchard is planted. Without this reserve, orcharding, or indeed any crop production, would be a hazardous undertaking unless one were assured of a supplemental supply.

The first soil samples were taken at the university fruit farm—our experimental planting located near Union, Neb. The results of the first determinations were startling, to say the least. These trees were 17 years old and planted 43 trees (30x33 feet) per acre in one part of the orchard and twice that thick where fillers had been used. In the latter case the trees are about 22.3 feet apart. In the filler block samples were taken as near the tree as possible and in the middle of the intersection approximately 15 feet from the tree, while in the permanent block the sampling stations were located at the tree, midway between trees (15 feet from the tree) and in the middle of the intersection (22.3 feet from the tree).

From the moisture percentages obtained through these determinations was then subtracted the hygroscopic coefficient percentage. Disregarding the figures for the upper five feet, the moisture content of which must be considered transitional—that is subject to replenishment by rains or removal by shallow-rooted crops annually—it was found that approximately 85 per cent of all available water had already been used in the filler block and about 65 per cent in comparable location (15 feet from the tree) in the permanent block. In other words, these thickly planted trees, 86 per acre, had in seventeen years used 60 to 70 acre-inches more water than they had secured from seasonal rainfall by withdrawing this quantity from the upper 30 or 35 feet of the soil. From now on these trees must depend almost entirely upon seasonal rainfall,

since there is no other water available for them. The soil in the filler block is dry all the way down, while in the permanent area conditions are not quite so bad. There is little question, however, but that even 43 trees per acre make a severe drain upon soil moisture. Perhaps right here lies the explanation of why apple trees in our territory do not live so long as the same varieties in other more humid regions. This explains, I believe, why we have few 40-to-50-year-old orchards in Nebraska. Most of them are 15 to 20 years old and as yet have not used up all the reserve moisture. Our first orchard crop came, grew, used up all the water and passed on perhaps during a drought period. The third or fourth orchard crop is now growing in Nebraska, and perhaps also in northeast Kansas and northwest Missouri.

With these results as a starter samples were taken in other orchards of different ages and spacings. From a 30-year-old orchard near Shubert some 65 per cent of the available water had been used, while in an adjoining 7-year-old planting only 5 per cent had been lost from a comparable location. A very interesting thing was brought out in a sample from another 7-year-old planting belonging to the same owner. In this case the orchard had been planted on an area which had already produced one crop of apple trees. Ben Davis trees set in 1890 had been removed in 1922. The soil had been used to produce ordinary farm crops until 1928 when it was again set to apples. In this area 30 per cent of the available water was gone in comparison with 5 per cent from the virgin planting. This surely indicates the folly of trying to introduce replants to fill vacancies in an old orchard in Nebraska and also of trying to plant another orchard on ground where one has been produced unless there is a longer interval than 7 years.

In another orchard near Shubert 80 per cent of available moisture below 5 feet had been used in 17 years and only about 5 per cent in 6 years in an adjoining planting. In this particular location there had been no influence on the moisture content below the 20-foot level—due, undoubtedly, to the presence of a soil layer into which or through which the roots could not go. As in the previous case, this indicates that for the first few years the tree's demands have little effect on the total available water supply. However, samples taken from the tree do show that depletion has begun and as time goes on the drain becomes heavier and heavier.

From the facts given above one begins to wonder whether the explanation given for the decline of the earlier plantings is a valid one. Diseases are usually mentioned, but it seems very probable that moisture deficiency may also have been a very potent factor. A tree weakened by lack of water will more quickly succumb to the ravages of canker, etc. Where the soil layer available for water storage is only 18 to 20 feet thick, naturally orchards cannot be expected to last as long as where 40 feet of soil, or even more, is available for root use.

In 1935 the work was continued mainly on the university fruit farm. Results showed that the driest area, considering all depths, is near the tree—the wettest the farthest away. Apparently then a tree begins to draw on sub-soil moisture at any time after planting when surface water is short. Depletion occurring at this time becomes progressively worse as the tree ages and extends both downward and laterally. In the permanent planting the relative usage of water at 1.5 feet, 15 feet and 22.3 feet from the tree were 47, 36 and 25 per cent. These figures are based on averages of about 25 samples and probably give a better picture of the actual situation than the figures given for the first

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In a nearby 19-year-old orchard samples were taken at the tree and from the intersection. At the tree approximately 60 per cent of the available water had already been used and about 35 per cent at the intersection. When single samples from Grimes and Black Twig trees are compared the Grimes area has already given up 80 per cent of its available water and the Black Twig about 35 per cent. This indicates that possibly varieties may have different water requirements which in turn may explain why some varieties are shorter lived than others. Figures for the Jonathan are close to those of the Grimes and those for the Winesap are comparable to those of the Black Twig.

The next question which comes up is, What can be done about all this? Can depletion be prevented, or if it occurs can a depleted supply be built up by proper management? We believe that there are some very definite things which can be done.

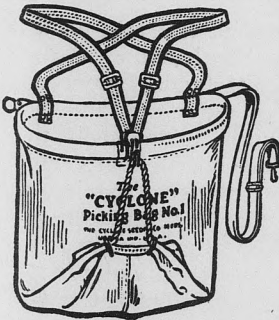
In the first place, never plant an orchard where one matured and then died, or on an alfalfa site, unless you are sure ample time has intervened to allow for moisture replenishment.

In the next place, forget all about compass direction and plant rows on the contour. Contour farming does check runoff—in fact, a little care from the orchardist in his planting may prevent it almost entirely. If all the rainfall can be gotten into the ground there probably is enough to grow good trees for a long time. However, if our rainfall is 30 inches or less, and as has been intimated, one third is lost by runoff and another one-third by evaporation other than through the trees, the remainder is just not enough to support the tree properly.

As a final step, don't plant too many trees per acre. Unquestionably fillers, in a region where rainfall is deficient, do lessen the life span of the orchard. If a certain number of trees must be used they should be scattered over more territory.

That some of the above suggestions are practical ones can be indicated by some further results obtained during the past season. Near Union is an

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area from which an old orchard was removed several years ago. Today that soil is just as wet down to a depth of 20 feet as is soil which has never grown trees. Below that level it is still dry. In Arbor Lodge State Park at Nebraska City is a white-pine grove set in 1890. In 1934 many trees, particularly in the center of the area, died either from lack of water or extreme heat or both. In December soil samples showed that between 5 and 25 feet there was very little available moisture. A year later moisture had been replenished to a depth of approximately 14 feet. In the meantime runoff and evaporation had been prevented by the needle cover and there had been little or no demand by plants for soil water because of the death of most of the trees. Undoubtedly in soils where water penetration occurs much more slowly, such as those found even within forty miles of the Missouri river, this replenishment process will proceed at a greatly reduced rate. In such areas the interim between orchard crops, or in fact any other deep-rooted perennial, will necessarily have to be considerably greater than in the river hill area.

On the university fruit farm is a vineyard now some 12 or 14 years old. A portion of this vineyard has been mulched with straw for ten years or longer while some nearby rows have been kept under clean cultivation. Soil samples taken at various times between December, 1934, and December, 1935, show that in the mulched area there is now as much or more soil moisture than in an adjoining field where only annual crops have been produced. On the other hand, something like 50 per cent of all available water below 5 feet has been used in the cultivated portion. Apparently, the mulch, by preventing all runoff and surface evaporation, has been able to so conserve rainfall that the needs of the plant have been supplied without depletion of the subsoil moisture supply. While mulching has its drawbacks, and in some cases may even be out of the question for orchards, this test at least gives a suggestion as to one solution.

Still another possibility may lie in the use of the basin lister. An attachment placed behind an ordinary lister makes dams across the furrow at specified intervals. Some orchardists already are using this contrivance with the idea of preventing runoff by holding the rainfall in these small basins until it soaks into the ground. Its use presents some practical difficulties so far as other orchard operations are concerned, but, even so, it should not be dismissed too lightly. Something of this sort may be the way out of the difficulties of the hill-orchard men who cannot now contour their planting or cover it with straw.

We, in Nebraska, appreciate the fact that we are at an extreme point in the orchard business so far as rainfall is concerned. South and east of us there is heavier rainfall, but even so, perhaps many Kansas and Missouri and Iowa and Illinois orchards are suffering, too. Some of our oldest and most productive orchards are located on second bottom, where undoubtedly they receive some runoff and probably also send roots down to the water table. Just what soil samples from this territory will show is a matter of conjecture, since none have been taken there as yet. My guess is that these trees are still well supplied with water or they would not be so large or so productive.

Still another interesting observation was made in connection with the root study mentioned in the beginning. In the fall of 1934, when things were very dry, the active root tips were very deep. Last spring (1935) after the upper several feet had been filled up again with water, the active tips were in this region. Consequently, it seems only reasonable to believe that the deeper roots draw actively on subsoil water only when it is not available to those near the



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surface. If all or most of the surface water can be saved for the use of the tree there seems little reason to believe that it will be insufficient.

As a final suggestion to the apple growers on the river hills through this territory, may I say that I believe you should use every means at your command to save surface water for tree use, and in Nebraska it may even pay to pump water from creeks or ponds back onto the orchard site where or when such supplemental water is available.

COLD STORAGE HOLDINGS

The Bureau of Agricultural Economics reports apple cold storage holdings as follows:

Barrels—May 1, 1938: 33,000; April 1, 1938: 83,000; May 1, 1937: 15,000. Western boxes—May 1, 1938: 2,331,000; April 1, 1938: 4,807,000; May 1, 1937: 2,258,000. Bushels—May 1, 1938: 3,357,000; April 1, 1938: 6,983,000; May 1, 1937: 1,226,000. Another frozen fruit storage report shows 20,167,000 pounds of frozen strawberries; 6,531,000 pounds of blueberries; 15,496,000 pounds of cherries; 52,898,000 pounds of other fruits—a total of 95,092,000 pounds.

THE BOX QUESTION

J. E. Linde, Manager, Orchard Division, Trexler Farms, Allentown, Pa.

There is no question of more vital importance in the marketing of apples at present than the question of boxes. The increase in use of boxes in the East has assumed such vast proportions the last few years that the question is uppermost in most growers' minds as to what style and size of box to use. To determine, for sake of economy the proper dimensions and size is no small decision to make—more so when we have about sixteen (16) different sizes to choose from. From a manufacturer's viewpoint, standardization of sizes and dimensions is pertinent to economy in manufacture. From a marketing standpoint the buyer is also at a loss as to know what he is receiving as far as quantity is concerned, when different sizes are used. From the packing end the grower should know what is best for him; how will the package fit into his scheme of things; has he the equipment to nail up boxes, as well as equip-

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ment to close after packing? Is he equipped to pack up number and count in a box, or does he wish to face and fill?

From my viewpoint, after using Western and Eastern boxes, as well as bushel baskets for a period of years, I have come to the conclusion that the box pack is the ideal way to pack fruit. There is less loss to the retailer, compared to the basket and we all want our apples to look as good at the retailers store as when they left our packing house, thereby enticing consumers by the looks and condition of our product, to wish and demand more.

The Pennsylvania Horticultural Society, in January, adopted the net bushel box, as well as the one and one-fifth ($1\frac{1}{5}$) bushel box; the net bushel to be used for layering and packing numerical count as the West is doing; the one and one-fifth ($1\frac{1}{5}$) bushel box for "face and fill."

The West Virginia Horticultural Society did likewise at their meeting in February. The Maryland Society endorsed only the one and one-fifth ($1\frac{1}{5}$) bushel box; feeling that that box filled their requirements, but mainly as a step toward standardizing the box size.

The one and one-fifth ($1\frac{1}{5}$) bushel box is an ideal package, providing it is not layered throughout. When layered throughout, it takes more apples to fill and when the lid is crowned, still more. Packed correctly the lid should be flat, not bulged. My suggestion for the size specifications on the one and one-fifth ($1\frac{1}{5}$) bushel box is as follows:

11 inches deep —	Inside measurements
14 " wide —	" "
17 " long —	" "

The following specifications are for the net bushel box.

11½ inches deep —	Inside measurements
12½ " wide —	" "
15 " long —	" "

We find after packing by count and number in the above box over a period of three years, that it holds the same amount of the same size apples as the Western box; is easier handled, and with a $\frac{1}{8}$ " thick lid and bottom does not bruise the fruit.

I earnestly hope the fruit growers from the Eastern Atlantic area will determine to adopt these sizes as standard—so export, as well as domestic, purchasers may know what they are receiving.

The bushel basket, as now used, with a crown lid does not hold any more apples than either of the boxes mentioned, the three are identical as far as capacity is concerned. There are quite a few advantages in the box compared to the bushel basket; handling is one; loading in trucks or cars another; packing is a third; eliminating facers and forms cluttering up the packing house as well as replacing them when damaged. Storage charges is another. Stacking on pavements and in stores is one not to be overlooked with consequent damage to fruit when a bushel basket is used.

The fruit growers in the Appalachian area have the Eastern markets in the palm of their hands now. Are we going to improve our pack to establish the confidence in Eastern fruit it so richly deserves? My thought is—"Good Fruit in the best package; eliminating the off-grade and inferior fruit at the orchard. Let the consumer know what we are doing; how good Eastern fruit is; and then we will put Eastern fruit in first place in the markets at our door."

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APPLE BOX CONFERENCE

Since the write-up was made, concerning the box, a conference was called in New York by the Massachusetts State Horticultural Association on May 13th, for the purpose of considering the possibility of standardizing the Eastern Apple Box or Crate. Representatives were present from Maine, New Jersey and Maryland. Letters were received from Ohio and Hampshire, Connecticut, Vermont, Rhode Island, New York, Delaware, West Virginia.

There has been 19 different sized apple boxes on the market. There were 6 sizes last year.

The unanimous opinion of the conference was that the box should be standardized, and the $1\frac{1}{5}$ bushel box was the one in favor. This box is in great use in New England, the $11\times14\times17$ inch box being most general. New York, however, felt that it would be better to make up a box that would hold $1\frac{1}{5}$ bushels, but of proper dimensions to load in a refrigerator car to best advantage. It was the general opinion of growers who used the box that there should not be a bulge, but a firm pack. The "face and fill" pack was general, but some chain stores want a jumble pack without a face. Mr. E. W. J. Hearty, a prominent apple exporter, stated that we should call it a box, not a crate. He also found that the trade was moving toward the box. There has been some feeling that the $1\frac{1}{5}$ bushel box gives the customer more apples than necessary. A New Jersey grower stated that this box holds the same amount of fruit as a crowned bushel basket, the apples being wrapped. One Maryland grower weighed the $1\frac{1}{5}$ bushel box and bushel basket, and found the average weight to be from 50 to 53 pounds. The legal weight of a bushel of apples in Maryland is 50 pounds. This would allow for 2 to 3 pounds weight of package. It was argued that even though there was more than a bushel of apples in the $1\frac{1}{5}$ box, the increase in price would probably take care of that, even including the extra cost of the box, plus packing costs.

Various railroad tariff men, also box manufacturers and representatives of the National Wooden Box Association and the Paper Box interests added interesting facts to the discussions. It was of interest to know that railroads can limit the amount of bulge on fruit packages accepted for transportation. Also, it was brought out that there was some competition in the markets between growers who had boxes of different size and weight, and the most weight usually won. Also, New Jersey considers the cubical content of a package as measured from the lowest point of the rim, or in case of a box, from the top of the side slat, instead of from the top of the end piece of the box, unless the side is higher than the end. The final conclusions of the conference will be given later when the report is received. Of course, any grower may use any size box that he desires, but it does seem best to have a box that will be a standard in any market. The only Government standard packages, at present, are the barrel, tub, climax basket and hamper.

A Swede was driving along a road in the South, when his car stopped. He found the trouble but needed a wrench to fix it. Spying a cabin, he went up, and found an old colored mammy washing clothes, and the yard around her was full of youngsters, all sizes and ages. Said the Swede, "Missus, Ay want to know have you got har a monkey wranch?" The indignant mammy said, "No suh, dis ain't no monkey ranch. Dey is all mah own chillun, dey is."

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